

# **Geological/Geophysical Studies in East Asian Marginal Seas, FY2002**

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## **LONG-TERM OBJECTIVES**

The long-term objective of this project is to understand more completely the shallow marine geology, surface oceanography, and recent geological history of the east Asian seas, particularly in light of the large sediment fluxes from present-day rivers and late Quaternary fluctuations of climate and sea level.

## **SCIENTIFIC OR TECHNICAL OBJECTIVES**

This study entails an analysis of existing data combined with acquisition of new geological and geophysical data from the continental margin surrounding eastern and southern China. Collectively they will facilitate better geological and geoacoustical models of east Asian marginal seas, particularly those with broad continental shelves.

## **BACKGROUND**

The seas east and south of China contain some the world's largest existent epicontinental shelves. The Yellow and East China seas (YS/ECS) have a combined width greater than 1200 km but water depths shallower than 100 m. The South China Sea shelf is considerably narrower, but the Gulf of Tonkin, with depths generally less than 80 m generally less than 100 m, is nearly 500 km wide.

Present-day morphology, surficial sediments, and shallow structure of both marginal seas reflect to a great extent the sedimentary input from adjacent rivers, the oceanographic regime, and post-glacial history. The Yangtze and Yellow rivers, which discharge into the YS/ECS, have had a combined sediment load of about 1.5 billion tons annually, whereas the Mekong and Red rivers, draining into the Gulf of Tonkin, have a combined sediment load greater than 200 million tons/year. These sediment fluxes, however, have varied greatly since the last glacial maximum (LGM), in response to regional climate change – particularly the re-initiation of the southwest monsoon (about 10-11 ka) - and the impact of deforestation and agricultural practices beginning about 3 ka. Superimposed on this changing sediment-input picture has been the non-constant rise of post-glacial sea level (as described below) during which sea level over the past 20,000 years has risen as a series of six rapid flooding events interspersed by long intervals of slow gradual rise (and perhaps some regressions). Complicating our ability to understand the present-day and historical situations, however, has been the uneven distribution and quality of oceanographic and geological/geophysical data necessary to achieve a comprehensive picture.

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For the past five years we have been studying the marine geology and shallow geophysics in the North Yellow Sea, a critical area in linking the Gulf of Bohai (present sink for Yellow River-derived sediment) and the South Yellow Sea. Research have been carried out in cooperation with the Chinese Academy of Science's Institute of Oceanology (Qingdao), Ocean University (Qingdao), and the Geography Department of the University of Nanjing. Two joint Chinese-VIMS geological and geophysical cruises in 1998 and 1999 to the North Yellow Sea and one joint Korean-VIMS geophysical cruise(1999) in the southeastern Yellow Sea provided new seismic and sedimentological data, which were combined with existing data to form an extensive data bank. This research has formed the basis for a PhD dissertation by Jing-pu (Paul) Liu, at the School of Marine Science, College of William and Mary. We will be using a similar approach in our study of the Gulf of Tonkin.

## **ACCOMPLISHMENTS AND RESULTS**

Based on the more than 1000 km of high-resolution (boomer) seismic data and 70 grab samples and box cores plus all the data gathered from the extensive Chinese literature, we have produced a number of scientific products relative to the Yellow Sea, particularly the North Yellow Sea. All seismic data have been archived in a GIS (ArcView) database and copies have been provided to NAVOCEANO (along with navigation data) as a series of CD-ROMS. In addition to preparing a series of papers, some of which have already been published (Liu et al., 2002) or submitted (Milliman and Liu, in review), we have one manuscript (Sedimentary Processes of the Yellow River's subaqueous delta in the North Yellow Sea. Liu et al.) soon to be submitted to Marine Geology. We also are preparing a paper that deals with the post-glacial history of the East China and Yellow seas, which also will appear in a special issue of Marine Geology (guest edited by Milliman, Yang and Saito).

As described in last year's annual report, the most significant achievement in our Yellow Sea study has been identifying what we believe to be a step-wise rise in post-glacial sea level. We have noted six short (100-300 years) periods of rapid sea-level rise in which sea level rose as rapidly as 100 mm/yr, separated by longer periods (500-2500 years) during which sea level rose at more moderate rates, 0-8 mm/yr. The significance of this finding is elaborated in the following section.

This year also has seen the initiation of a new cooperative research program between Haiphong Institute of Oceanology (Vietnam), Nanjing University (China) and VIMS (USA) for the study of the marine geology of the Gulf of Tonkin. Much of this cooperative agreement was arranged and discussed during an informal meeting in Nanjing in April of this year. As envisioned, we have proposed a series of three cruises, two on Vietnamese ships that will delineate the geological and geophysical regime of coastal waters off Vietnam and one cruise on a Chinese ship that will obtain similar data west of Hainan Island. To facilitate Vietnamese and Chinese approval of this project, we have enlisted the sponsorship of the IGBP LOICZ (Land-Ocean Interactions at the Coastal Zone) program. The first cruise is scheduled for April 2003, although final approval depends on the outcome of our forthcoming visit to Haiphong and Hanoi in October (2002).

## **IMPACT ON SCIENCE**

Defining the importance of step-wise sea-level rise combined with climate change has allowed us to produce a short film-strip that highlights the episodic sedimentary history of the post-glacial Yellow Sea. The overwhelmingly positive acceptance of this film-strip by various audiences, in fact, caused us to show (and reshoot) it at NAVOCEANO, Scripps, Woods Hole, and numerous Chinese institutes and universities, as well as being invited to present a paper at the Autumn AGU Meeting in San Francisco.

The impact of this discovery, however, extends beyond the post-glacial history of the Yellow Sea per se, since it also suggests (strongly) that the step-wise rise of sea level should be reflected as a series of distinctive flooding surfaces on the continental margin as sea level back-stepped during the rapid transgressions. Recently we have seen high-resolution seismic profiles from the southern Japanese inner shelf, verified by deep borings, (F. Masuda, written communication), that indicate several flooding surfaces related to rapid sea-level rise. Now that we know what to look for, and with better high-resolution seismic techniques, we suspect that similar flooding surfaces will be seen in many other shelf clinoforms.

## **SUBMITTED PAPERS**

- Liu, P., Milliman, J.D. and Gao, S., 2002. The Shandong Mud Wedge and Holocene Sediment Accumulation in the Yellow Sea. *Geomarine Letters*. 21, 212-218.
- Milliman, J.D. and Liu, J.P. Timing and rate of sea level rise during melt-water pulses 1A and 1B. *Geology*, in review.
- Liu, J.P., Milliman, J.D., Gao, S. and Cheng, P. Sedimentary processes of the Yellow River's early subaqueous delta in the North Yellow Sea. *Marine Geology*, submitted.

## **ORAL PRESENTATIONS AND INVITED TALKS**

- (Milliman) River Delivery and Fate in the Global Coastal Ocean. Scripps Institution of Oceanography, March 2002
- (Liu) Post-glacial sea-level history and development of the Yellow Sea. Scripps Institution of Oceanography, March 2002.
- (Milliman) River Delivery and Fate in the Global Coastal Ocean. Tonji University, April 2002.
- (Liu) Post-glacial sea-level history and development of the Yellow Sea. Tonji University, April 2002.
- (Milliman) River Delivery and Fate in the Global Coastal Ocean. East China Normal University. April 2002.
- (Liu) Post-glacial sea-level history and development of the Yellow Sea. East China Normal University. April 2002.
- (Milliman) River Delivery and Fate in the Global Coastal Ocean. State Oceanic Ocean University, April 2002.
- (Milliman) River Delivery and Fate in the Global Coastal Ocean. Chinese Academy of Science, Qingdao, April 2002.
- (Liu) Post-glacial sea-level history and development of the Yellow Sea. Chinese Academy of Science, Qingdao, April 2002.
- (Milliman) River Delivery and Fate in the Global Coastal Ocean. Nanjing University, April 2002.
- (Milliman) Post-glacial sea-level history and the significance of periodic flooding events. Nanjing University, April 2002.

- (Liu) Post-glacial sea-level history and development of the Yellow Sea. Nanjing University, April 2002.
- (Milliman) Global Rivers and the Yellow Sea. Naval Oceanographic Office, Stennis Space Center, MS. May 2002.
- (Liu) Post-glacial sea-level history and the significance of periodic flooding events. Woods Hole Oceanographic Institution, August 2002.